Effective Procedure for Improvement of Light Aids to Navigation through Simulator Experiments

Keiko MIYAZAKI, Masayoshi NUMANO, Kunihiko TANAKA, Yoji MUROHARA, Tadatsugi OKAZAKI, Junji FUKUTO, Yasuyuki NIWA, Masato TAKAHASHI
Ship Research Institute, Ministry of Transport
6-38-1, Shinkawa, Mitaka, Tokyo 181-0004, Japan

1. INTRODUCTION

Light aids to navigation, such as lights mounted on buoys and lighthouses, are very important facilities that allow marine traffic to continue at night. Although the passage of a vessel is determined by laws and regulations, there is room for improvement on the passages and thus on the placement of lights which define the passages. If a given passage is difficult to navigate along and the situation thus needs to be improved, every improvement should be evaluated before an actual construction takes place. Any new system for using light aids to navigation should also be evaluated before it is applied to an actual situation. A ship-handling simulator has a possibility that does these evaluations conveniently.

We reported on a technical approach to the effective representation of light aids to navigation by the use of computer graphics in a ship-handling simulator at MARSIM'96 [1]. Since then we have built a new ship-handling simulator with some new characteristics to be used efficiently. We have also created an effective procedure for evaluating the navigational environment, including light aids to navigation, in a ship-handling simulator. Our procedure allows effective evaluations. We also applied new architecture to the ship-handling simulator. We will introduce the procedure and the characteristics of our simulator in this paper.

2. PROCEDURE FOR EVALUATIONG THE NAVIGATIONAL ENVIRONMENT

In general, there will be several ways in which the difficulty of navigating along a certain passage may be reduced. There are also various ways in which light aids to navigation can be better applied to improve a layout of a certain passage. We aim to efficiently evaluate the various alternatives by using our ship-handling simulator. Figure 1 shows the procedure for evaluating the navigational environment, including light aids to navigation. We first select a particular passage to be improved. We then study actual navigation along the selected passage by charts of the seas in the area and field research with expert mariners. And we create models the navigation including the navigational environment.

In the next stage we determine which elements of the navigational environment can be represented graphically in the simulator. We can then set up the simulated navigational environment. We have applied new architecture, data-driven method, to our simulator. Here this involves the creation of a data file, the creation of object data for the computer graphics, and the creation of the algorithm, which runs the simulation. In these three areas, we have introduced some new features to the simulator. They are described in the next chapter.

With these preparations complete, we perform a first set of simulator experiments and evaluations. An additional round of fieldwork follows, in which we compare the appearance of the simulated and real worlds. Here we pay attention the navigation itself and the relationship between light aids to navigation and background lights as navigational information and disturbance. When the simulated world lacks necessary information, the computer-graphic objects are modified. The data files and algorithm are altered as the occasion demands.

Final rounds of simulator experiments and evaluations follow. If the evaluations indicate that some improvements are required, the data for the computer-graphic objects is supplemented, or the programs are improved. The alterations are then evaluated by further experiments. Using the simulation we evaluate improved systems of light aids to navigation.

3. ARCHITECTURE OF THE SIMULATOR

Our ship-handling simulator has some characteristics to be used efficiently. Our simulator is data-driven. A Scenario of a simulation can become a data file to run the simulation directly. The data file indicates a place of a simulation area, characters such as ships, buoys and landmarks and initial conditions of them.

Our simulator adopts UDP (User Datagram Protocol). Figure 2 shows the elements that compose the simulator. We use PCs as graphics computers. UDP communication methods ensure a robust system and to make the PCs to create computer graphics simultaneously.

3.1 CREATING THE DATA FILE

Our simulation is data-driven. The program thus does not be rewritten for each situation. Our program reads a predetermined control file. The control file contains the names of files that carry the simulation data. There are a number of file types, and they are described in the next paragraph. The program reads the data from the indicated files. We only need to change the contents of the control

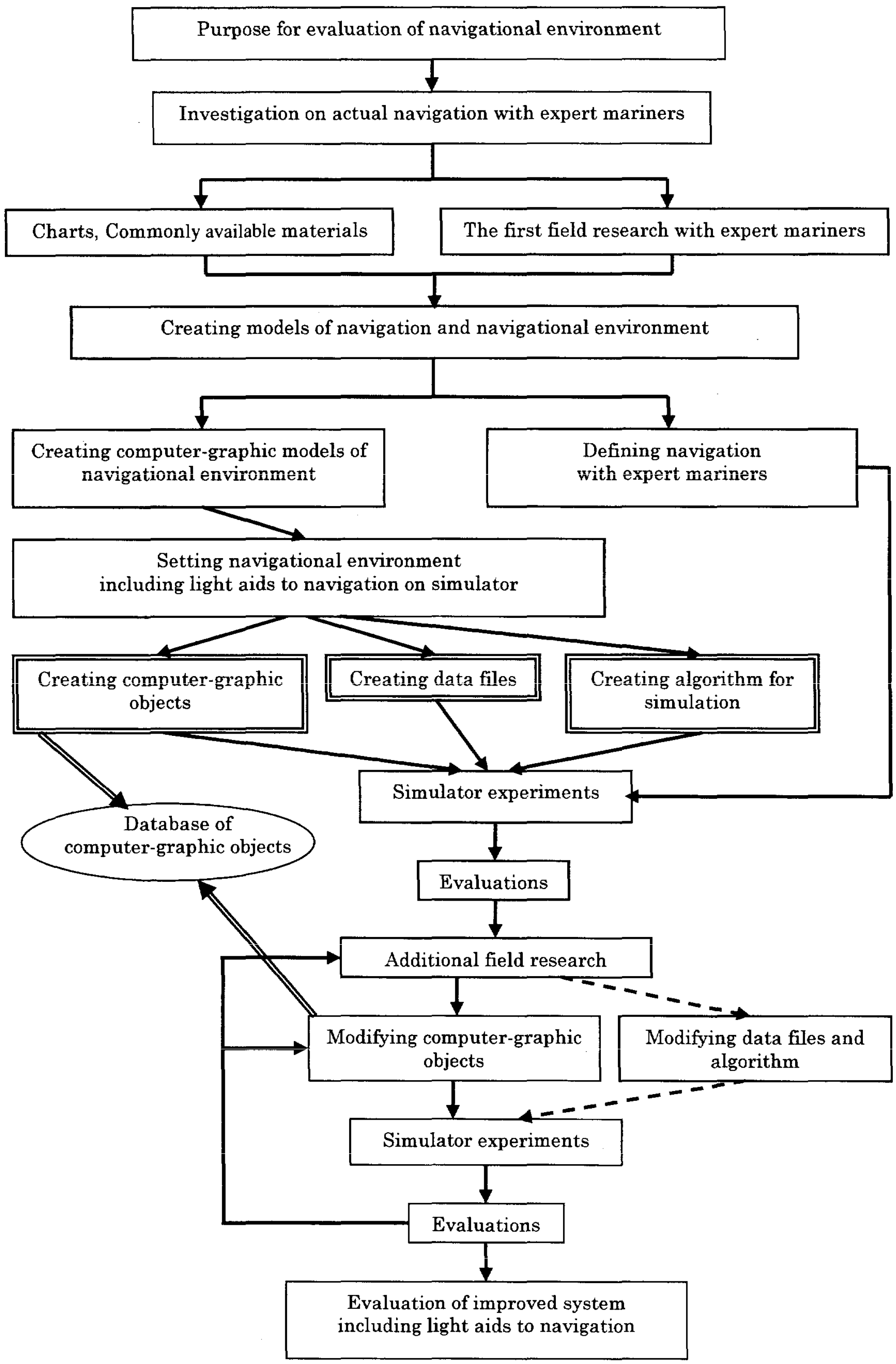

Figure 1 Procedure for Evaluating the Navigational Environment

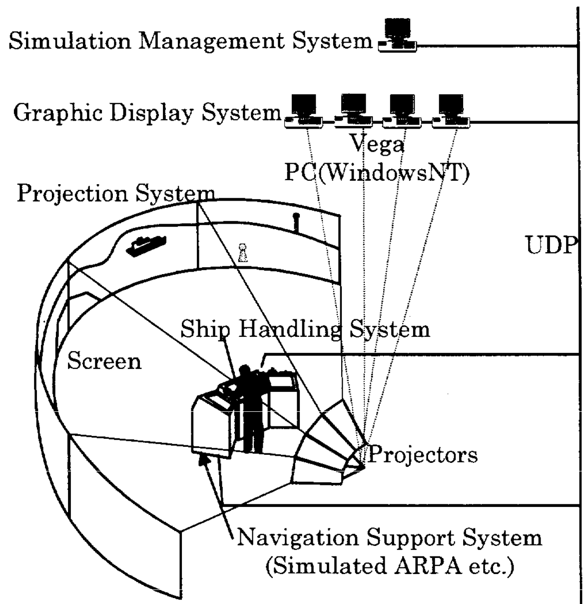

Figure 2 The Elements which Compose our Ship-Handling Simulator

file and set up new data files to simulate a different area. We can improve our simulator even when an actual simulation is executed.

We use four types of simulation data: ship data, light data, static object data, and dynamic object data. Ship data represents a ship in terms of such dynamic data as its position, speed, and heading. The light data represents the light on a buoy or in a lighthouse. Each light has a particular pattern of blinking (e.g. blinking twice at interval six seconds), as well as a position. The light data is simply a representation of charts of the area of sea that is being simulated. The light data also reflects some improvement of light aid system. Static object data includes representations of terrain objects such as a ground and mountains, and artificial objects such as the bodies of buoys. Such static objects stay in one place throughout a simulation. There are two types of dynamic objects: the first varies according to the time of day and represents background lights such as factory and city lights. The second type of dynamic object is controlled by the Simulation Management System, and the objects that are involved depend on the purpose of the simulation.

Every object, except for those in the static object data file has its own flag. The flag can be used to indicate that the dynamic object will change according to the time of day. The flag can also indicate that the object can be controlled by the Simulation Management System.

3.2 CREATING THE COMPUTER-GRAPHIC DATA FOR THE OBJECT

The way that objects are represented as computer graphics depends on their characteristics. Ships, the bodies of buoys, and the ground are generally 3-D objects. Background lights are represented by texture mapping.

A standard level-of-detail technique is used for the representation of objects such as ships. In the standard technique, a ship object becomes more distant, its representation becomes rougher. Even at the distant condition objects should have necessary information.

An improved level-of-detail technique must be used to represent the lights of buoys to keep their visible pixel size. This improved level-of-detail technique was reported on at MARSIM'96 [1]. As a light object becomes more distant, bigger polygons are used to represent it, and its luminance is darkened.

Figure 3 expresses, in outline form, the relation between size and luminance in the improved level-of-detail technique. As a light object's polygon size times its luminance is its luminous intensity, object's luminous intensity of each level-of-detail is the same numerical value. This technique dose not depend on a computer-graphic software on the market and represents the lights of buoys appropriately according to each luminous intensity throughout a large simulated area.

If there are dynamic changes of objects during a simulation, common light objects can be used and an algorithm can be used to choose the appropriate object according to its luminous intensity and its current distance as shown in Figure 4 [2].

Background lights consist of the light from many point sources, such as factory and city lights. The improved level-of-detail technique should be also applied to the texture mapped background lights, to maintain an appropriate luminous intensity throughout the simulated area. Figure 5 shows that, as a texture mapped object becomes more distant, the size of each point source must be increased, and the total number of point sources must be decreased [2]. It also keeps background lights object's luminous intensity of each level-of-detail equally.

The general terrain objects are also very important. Background lights, landmarks and buildings are set on the terrain. Mountains are often used as natural landmarks for navigation in a given area of sea in the daytime. Representing the general terrain objects is not, however, easy. We used a digital map that is issued by The Geographical Survey Institute of Japan to create these objects. The use of such an easily accessible source helps make the whole computer simulation system more efficient.

The computer-graphic object data is accumulated in a database and can be efficiently used in other simulations.

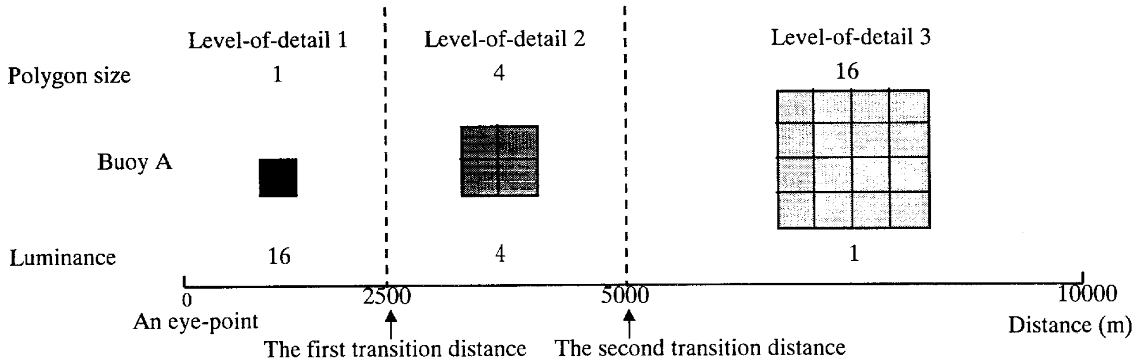

Figure 3 Outline of the Relation between Size and Luminance in the Improved Level-of-Detail Technique

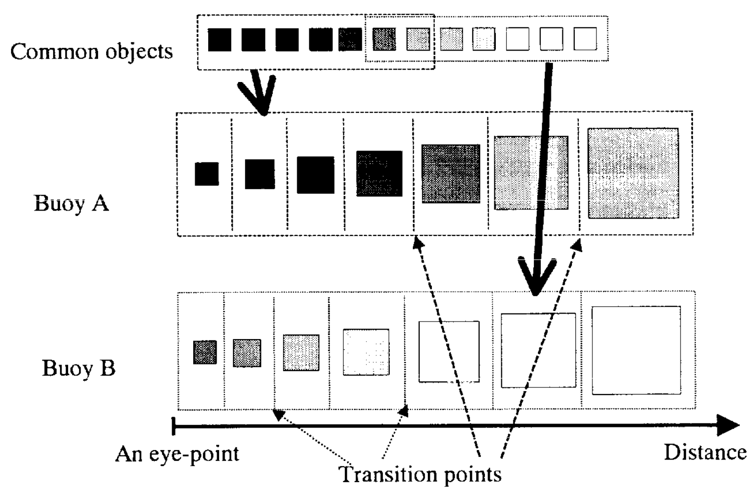

Figure 4 Outline of the Method of Selection of a Representation from among Common Light Objects

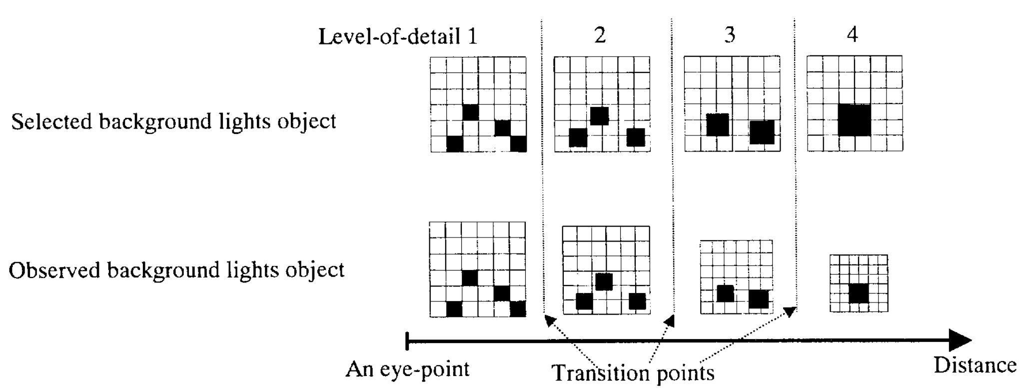

Figure 5 Outline of the Representation of Background Lights by Texture Mapping with the Improved Level-of-Detail Technique

3.3 CREATING THE ALGORITHM FOR SIMULATION

We have created keyboard operation functions to be controlled by the Simulation Management System. The behavior of dynamic objects, ship objects and light objects can be altered by keyboard operations based on the value of a flag in the object's data file. Different flags in the data file for light objects mean different sets of patterns of blinking. The flags and the items that can be varied are selected according to the scenario and the purpose of the simulation.

4. SIMULATOR EXPERIMENT

We simulated Tokyo Bay by using the new functions explained above and ascertained effectiveness of the procedure with evaluations by experts of light aids to navigation. Figure 6 shows a scene of the simulation in the evening. A light of a buoy on the sea and background lights on the ground are seen. Buildings and mountains are also expressed in the dark.

We have been experimenting with simulations of Yokkaiti Port in Ise Wan (the Gulf of Ise) in the central Japan by applying this procedure. The purpose is to examine new light systems that will help to improve navigation in Yokkaiti Port. Various alternative sets of patterns for lights of buoys, including methods of grouping them so that they blink in a cascade or are synchronized, etc., are investigated and an optimal combination can be discerned. We can easily change various sets of lights to find out an optimal condition of light aid system.

We have finished the first round of simulator experiments and evaluations of the procedure. The second round of field research has just been done at the end of January in 2000. The final evaluations of the improved light aid system will be executed in early March. The results of the evaluation to improve navigation in Yokkaiti Port will be presented at UJNR-MFP in May.

5. SUMMARY

In this paper we have introduced an effective procedure for evaluating navigational environments including light aids to navigation in a ship-handling simulator. Noteworthy points are the abstraction of the characteristics of the navigation and the navigational environment with expert mariners. A further noteworthy feature is the additional round of field research to complete the simulation program and data.

We have applied new architecture to the ship-handling simulator. The features are summarized in the following list.

- Realizing the simulator as a parallel process on multi PCs via network communications using the UDP
- Data driven method
- Using flags in the data files to alter the behavior of the simulated objects
- Flag control to enable new light patterns to be evaluated
- Representation of light objects and textured background lights objects by the improved level-of-detail technique without depending on a computer-graphic software on the market
- Making use of digital maps as data sources

These functions are useful, not only for the evaluation of the navigational environment, including light aids to navigation, but also as a general ship-handling simulator.

REFERENCES

[1] Masayoshi NUMANO (1996), "Effective representation of light aids to navigation in ship-handling simulator", Proceedings of International Conference on Marine Simulation and Ship Maneuvering, September, pp.13-20.

[2] Keiko MIYAZAKI and others (1997), "Improved Representation of Light in Ship-handling Simulator and its Application to Kanmon Passage" (in Japanese), The Journal of Japan Institute of Navigation Vol.97, September, pp.201-211.

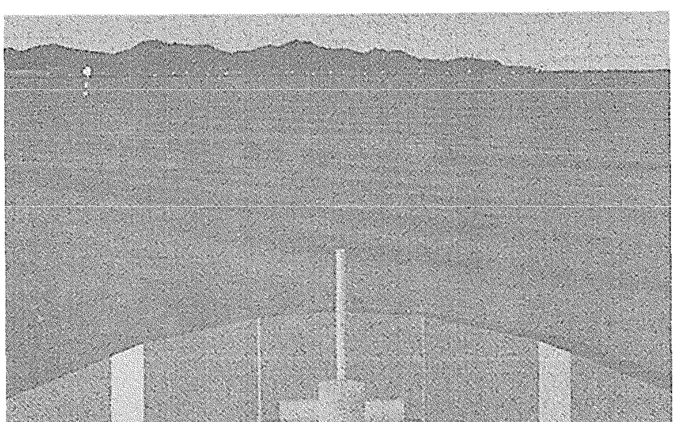

Figure 6 A Scene of the Simulation in Tokyo Bay